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Stabilization and the Energy Sector

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Outline

- Stabilization Basics
  - Definitions
  - Historic data and future projections
- Recent Stabilization Scenario Analysis: EMF 22
  - Crosswalk between EMF 22 scenarios and policy proposals
  - Insights related to incomplete participation
  - Insights related to technology

Stabilization Basics

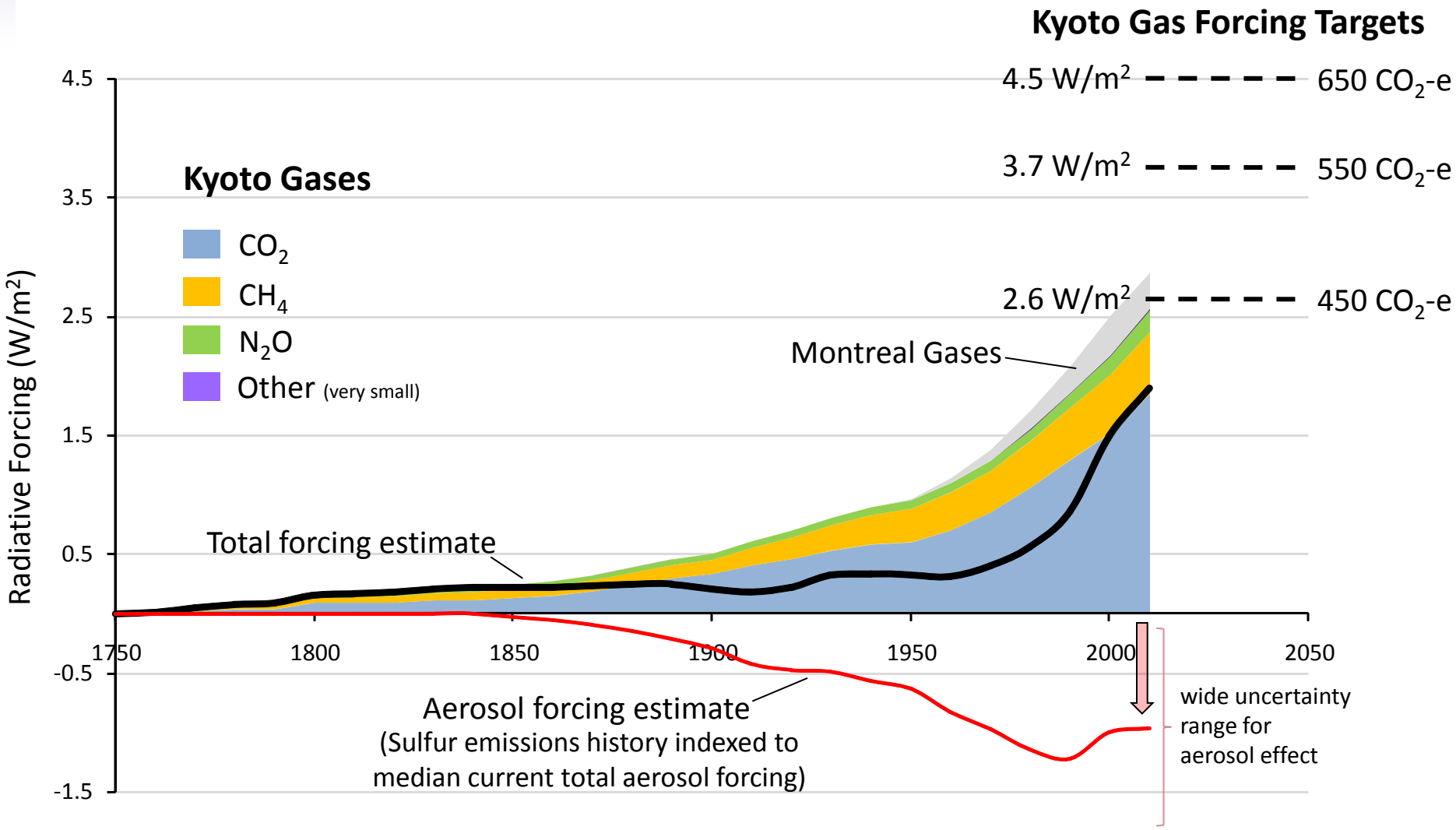
- Emissions →

  Concentrations →

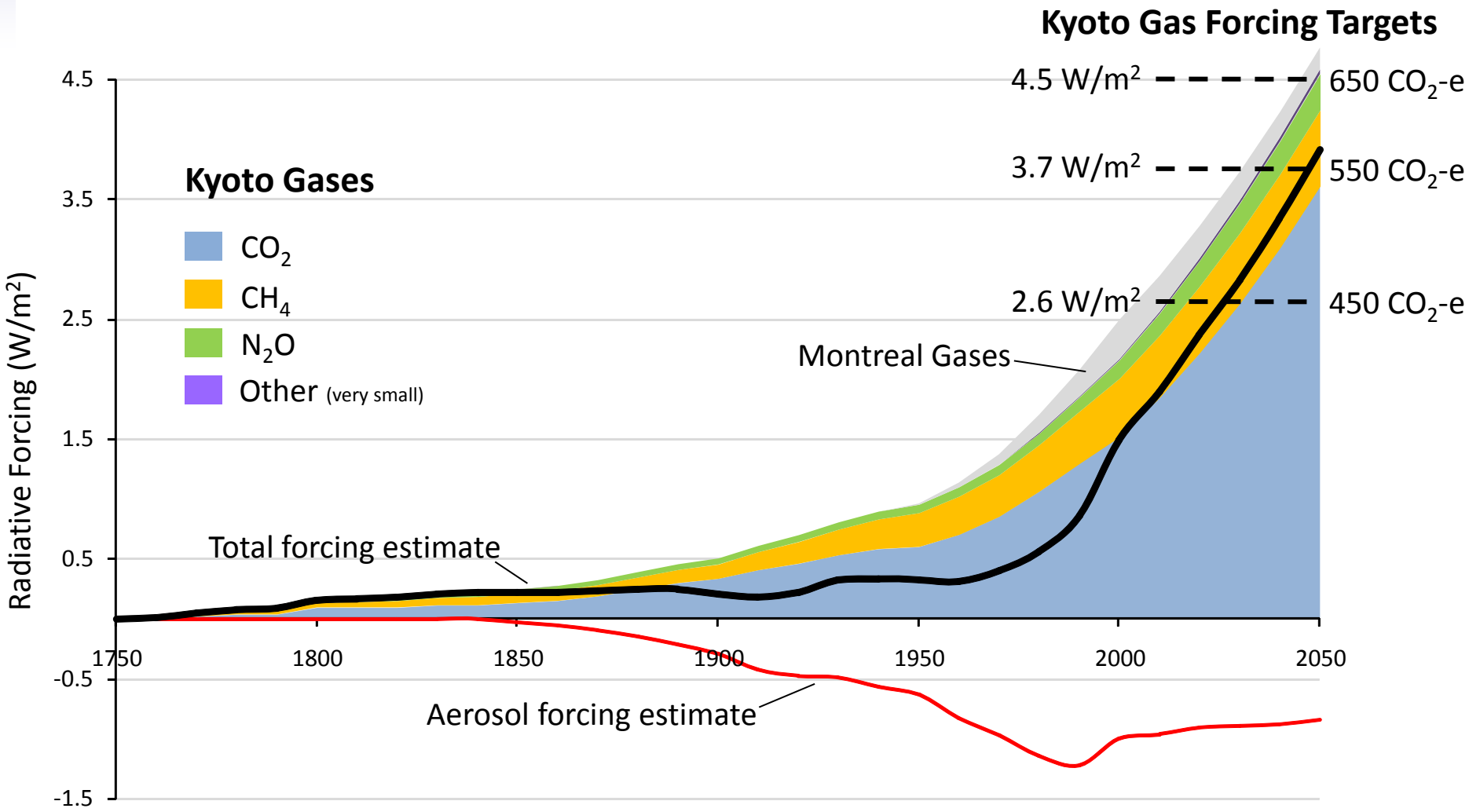
  Radiative Forcing = change in Earth's heat balance

- Many forcing agents, including long-lived gases and aerosols
- Agents have different properties, but (global) forcing is additive
- Kyoto Protocol applied to all greenhouse gases (except ozone-depleting gases covered by Montreal Protocol), **not** to aerosols
- Total forcing from Kyoto gases can be expressed as a "CO_2 equivalent concentration" – refers to the concentration from CO_2 alone that would cause the same forcing level

Historic Global Greenhouse Forcing



Greenhouse Forcing Projections in MERGE BAU



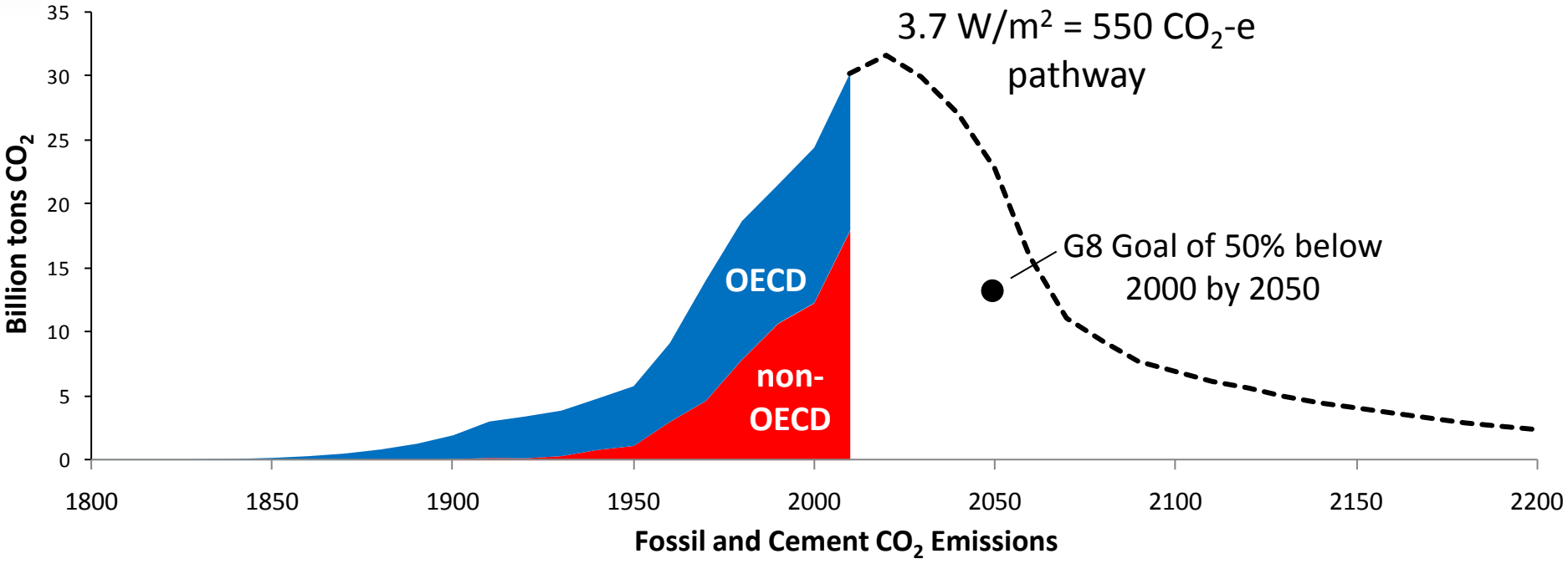
What does stabilization mean for temperature?

- Depends on climate sensitivity and thermal lags
  → Both are ***very uncertain***
- Climate sensitivity is defined as the equilibrium temperature increase in response to ***sustained forcing*** equivalent to a doubling of atmospheric CO_2 (i.e. 550 CO_2-e or 3.7 W/m^2)
- Median value from IPCC is 3°C, scales linearily with forcing

550 CO_2-e	=	3.7 W/m^2	→ 3°C (median)
450 CO_2-e	=	2.6 W/m^2	→ ~2°C (median)

- With "overshoot", all bets are off

What does stabilization mean for emissions?

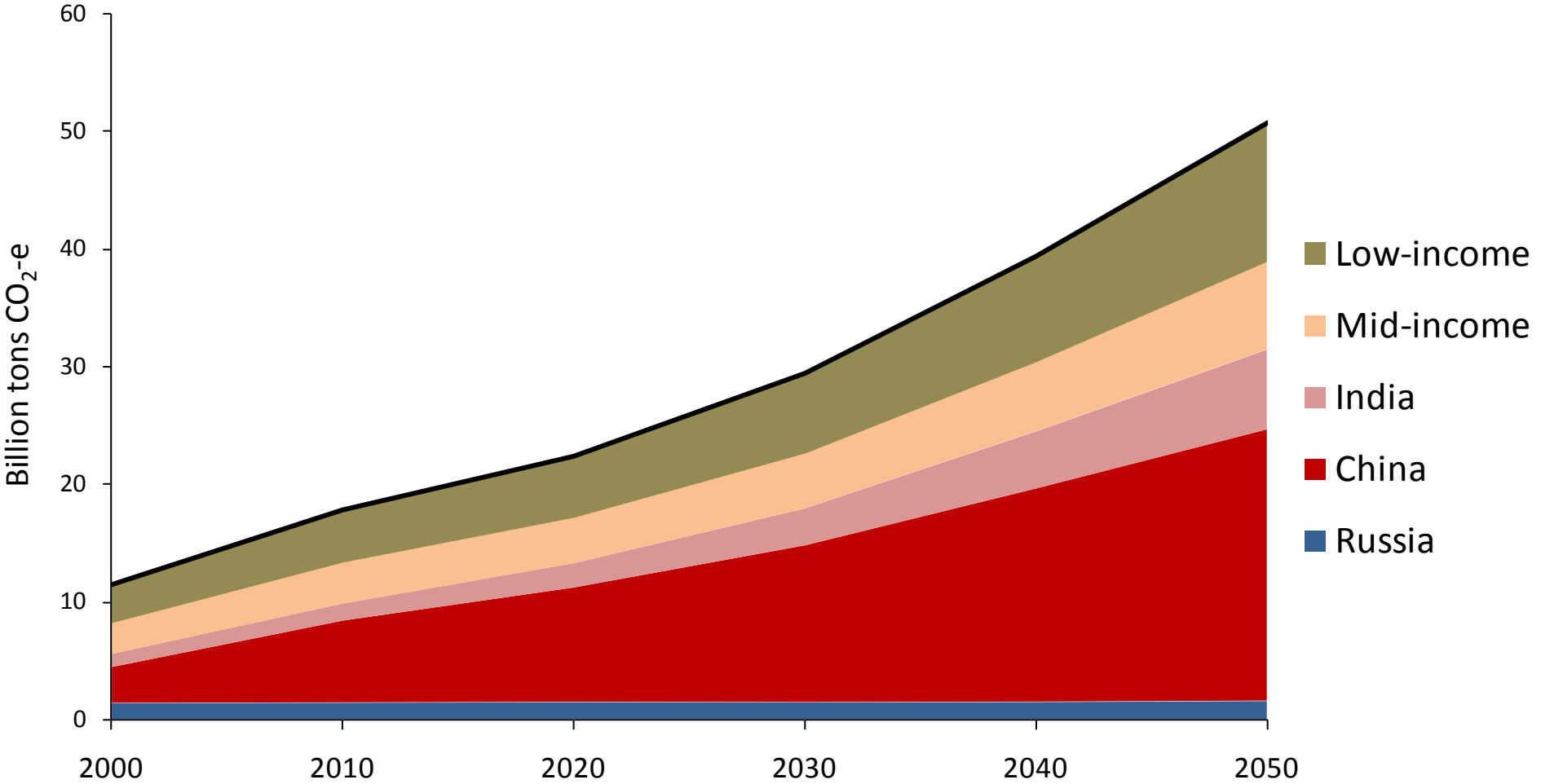


50% global reduction below 2000 levels +

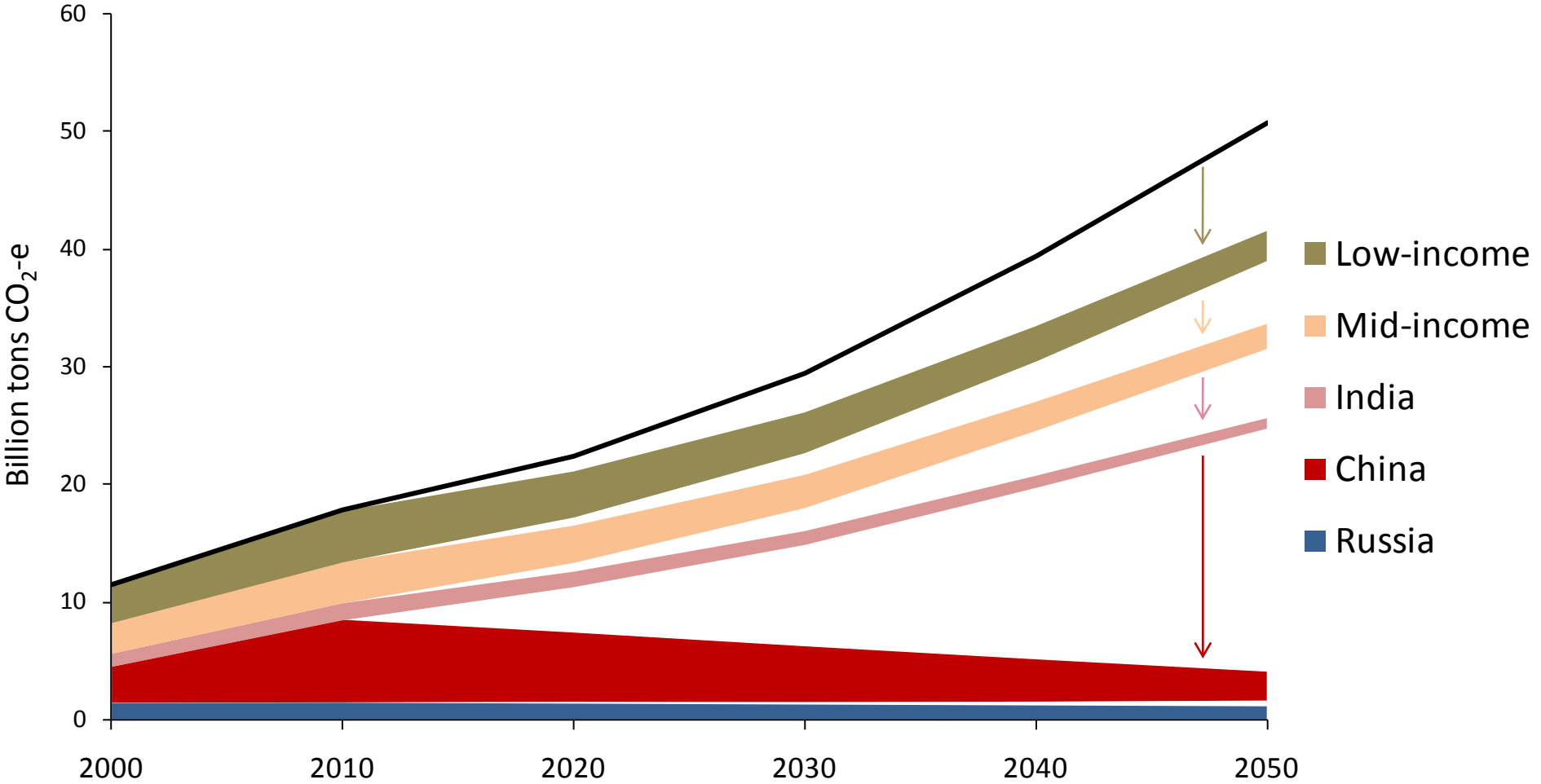
80% below for OECD ⇨

20% below for non-OECD

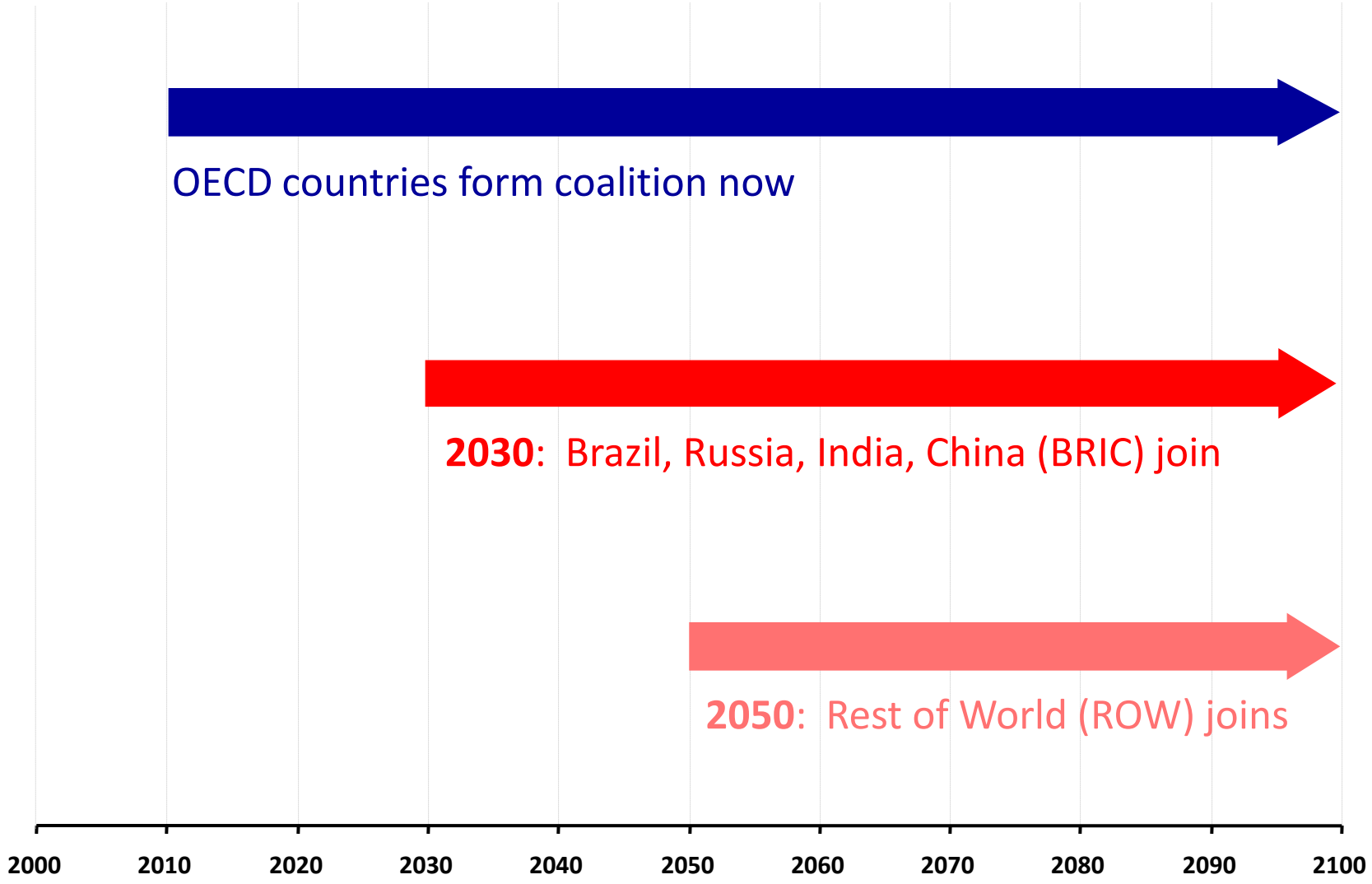
Baseline Emissions for Non-OECD



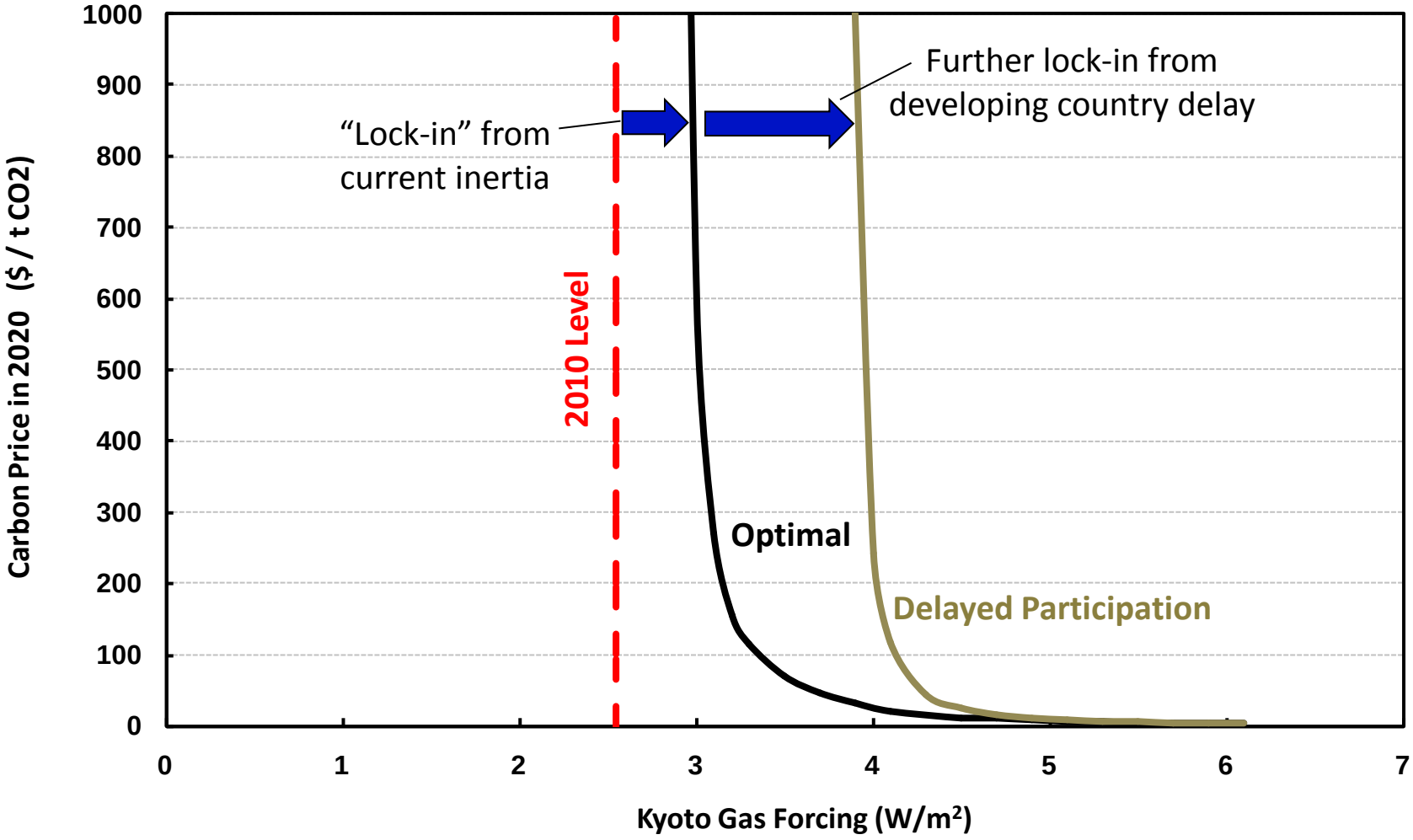
20% below 2000 = 80% below BAU in 2050



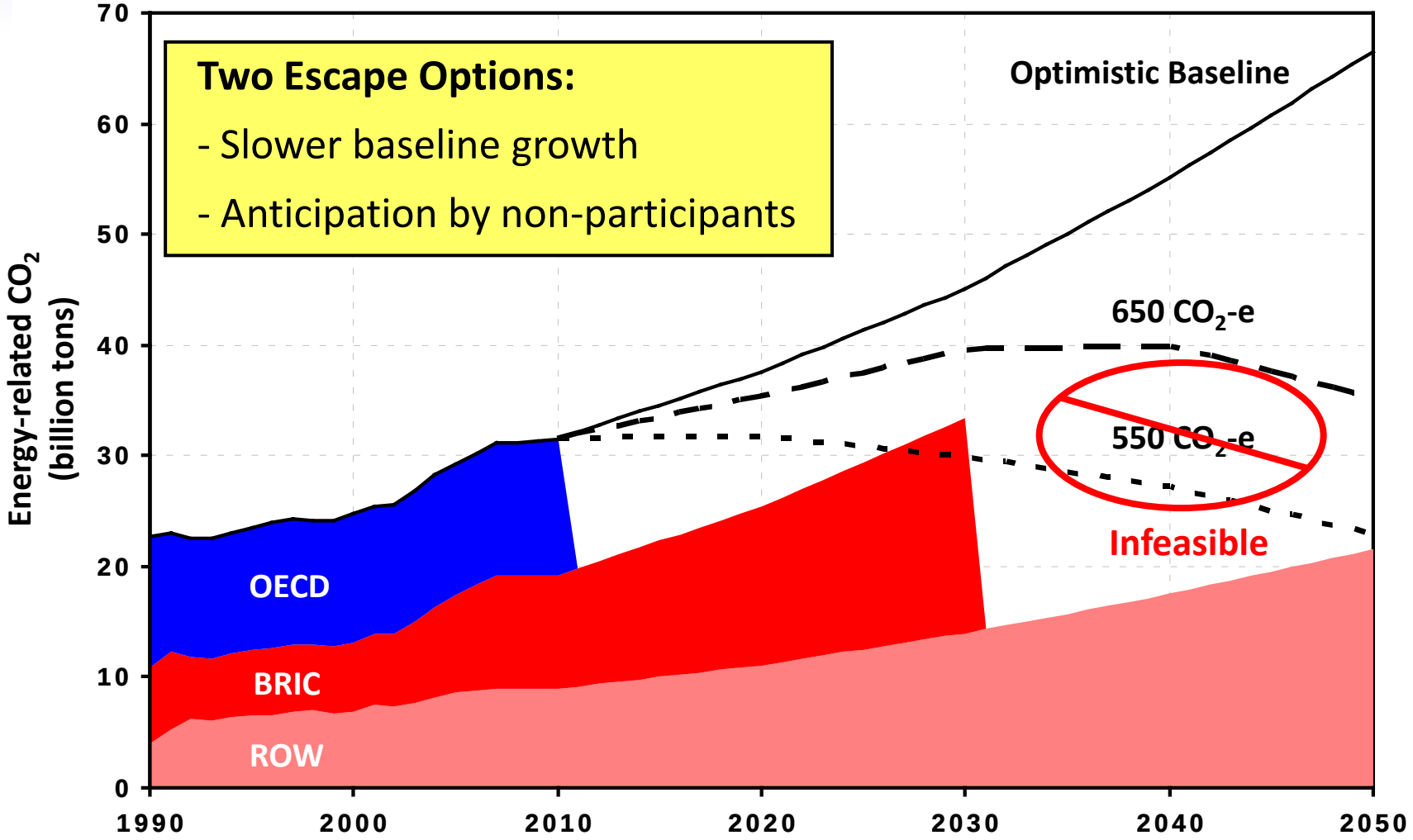
EMF 22 Delayed Participation Storyline



Cost Asymptotes for Stabilization in MERGE



Emissions before joining coalition by group



What does stabilization mean for technology?

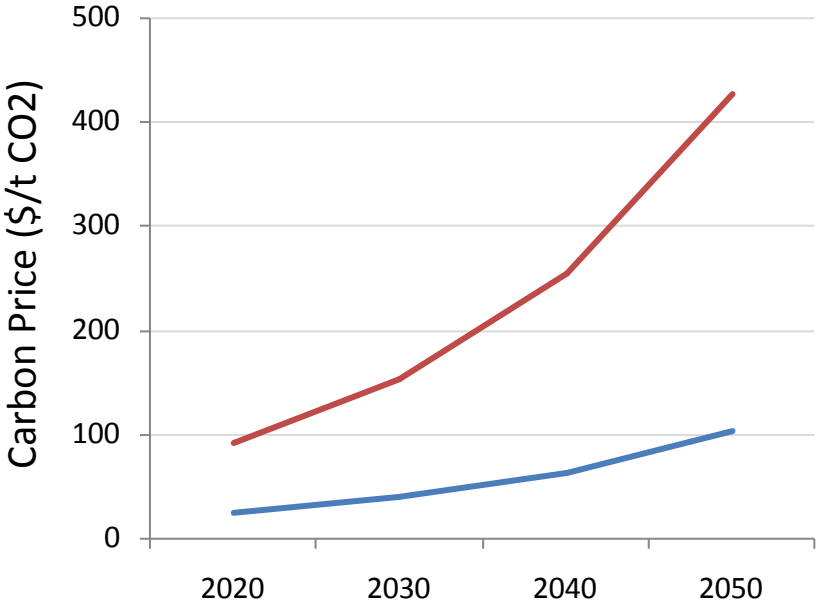
- Transformation of energy systems has two main attributes:
  - De-carbonization of electric sector
  - Electrification at end-use

- Key electric sector technologies:
  - Carbon capture and storage (CCS)
  - Nuclear
  - Renewables, particularly wind and biomass
  - Increased supply cost drives big changes on demand side

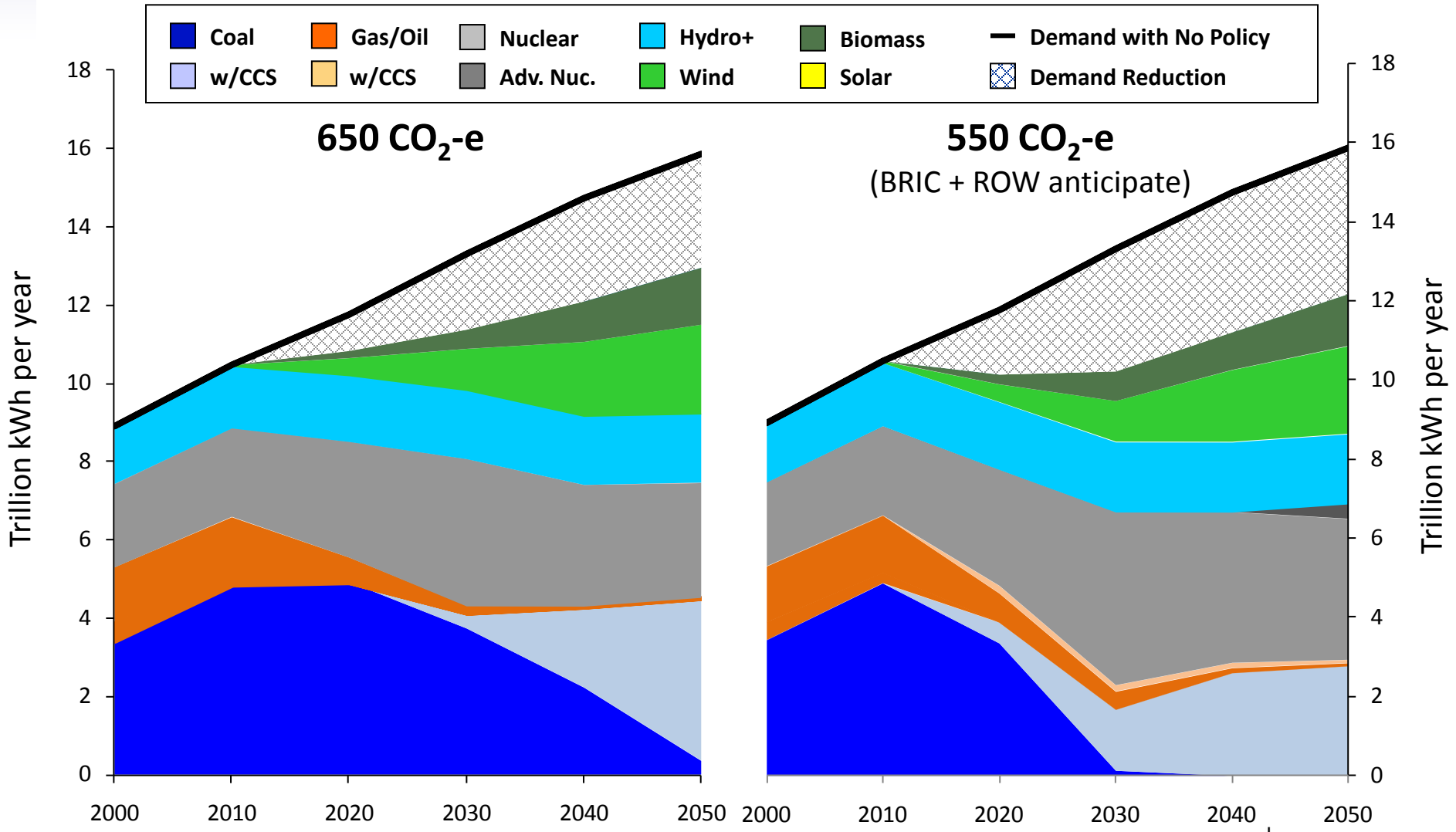
Global Technology Scenarios in MERGE

- OECD and developing countries will rely on the same technologies, but dynamics and scale will be very different

- Consider two stabilization scenarios with delayed participation:
  - 650 CO_2-e (*no anticipation by developing countries*)
  - 550 CO_2-e (*developing countries anticipate future targets*)



Electric Generation in OECD (Effect of Target)



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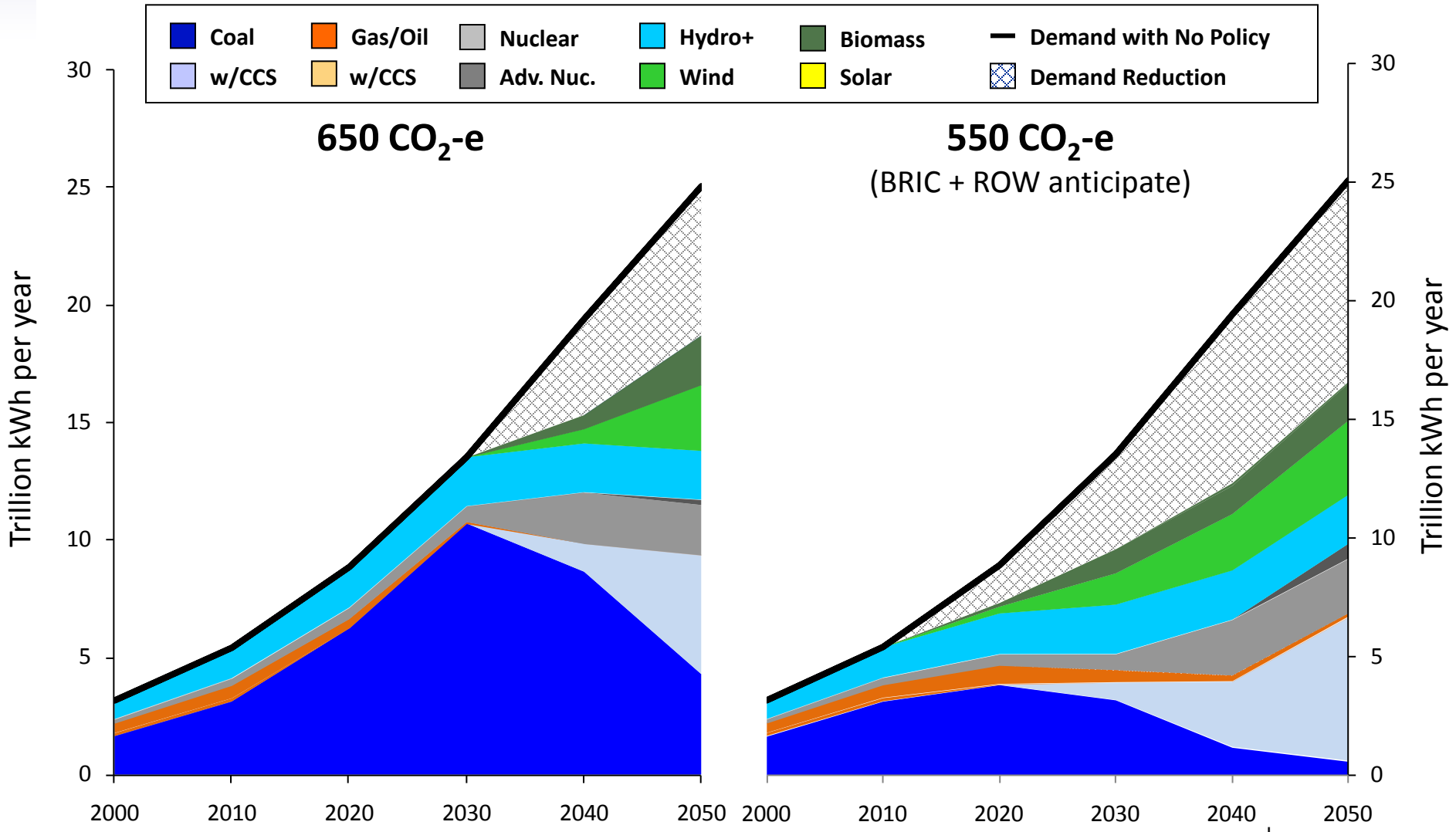
Electric Generation in BRIC (Effect of Target)



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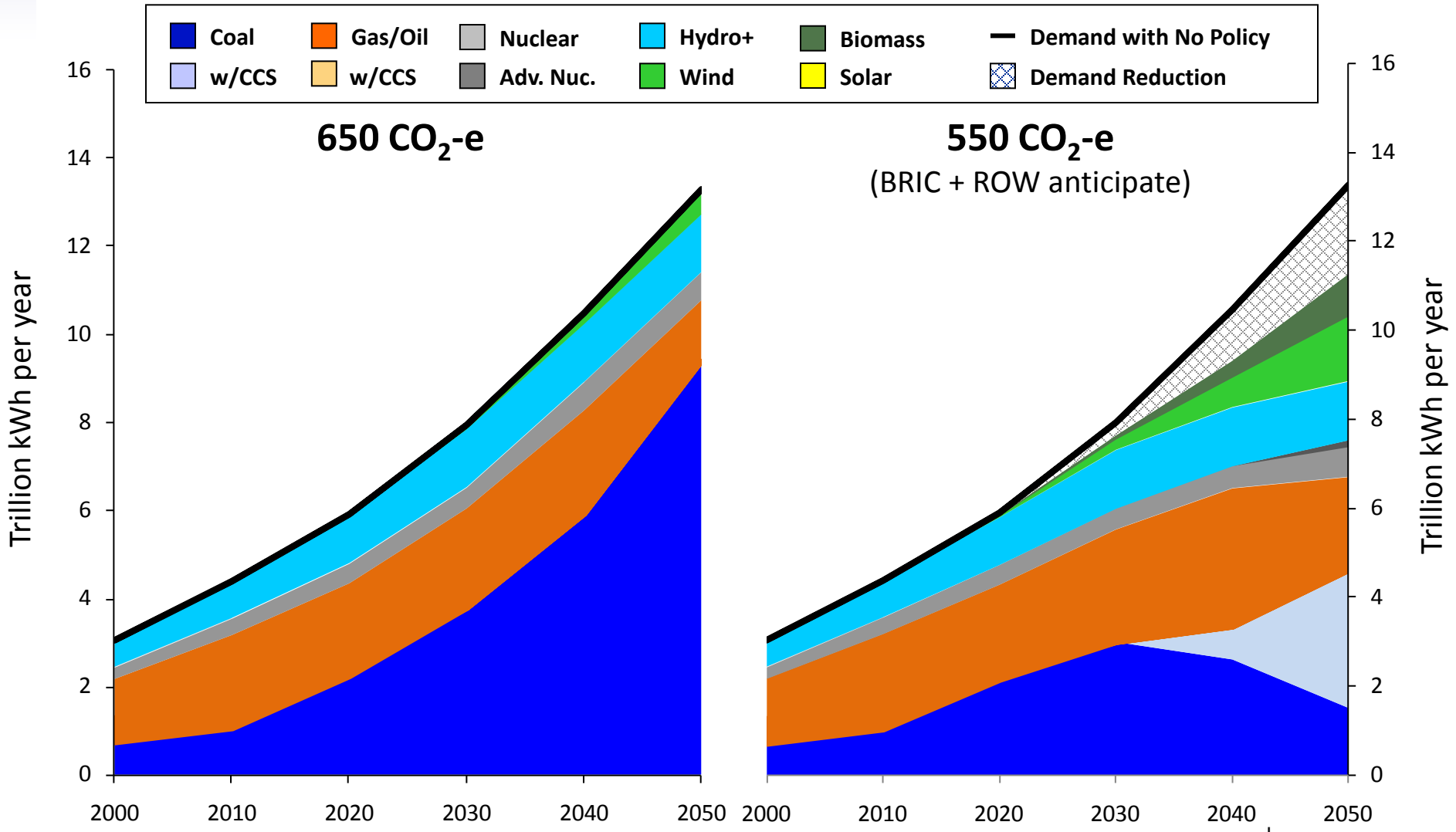
Electric Generation in ROW (Effect of Target)



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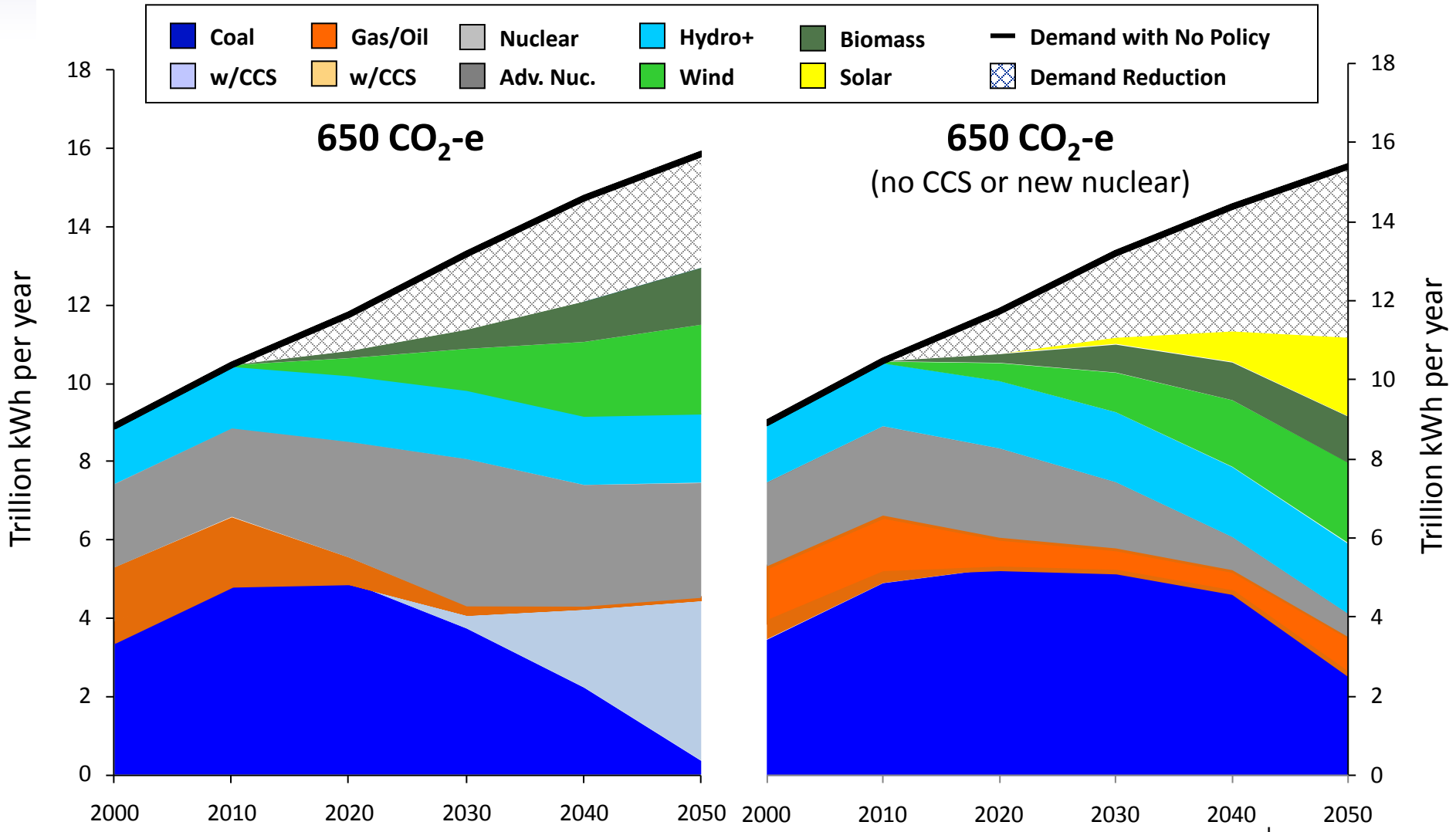
What happens without CCS or New Nuclear?

- 550 CO_2-e scenario no longer feasible (even with anticipation)
- 650 CO_2-e scenario more expensive
  - More reliance on higher cost renewables
  - More demand side changes with higher prices
- Increased total cost is a measure of the value of technology
  - ~$1 trillion in US alone (in 650 CO_2-e scenario)
  - ~$10 trillion globally

Electric Generation in OECD (Effect of Technology)



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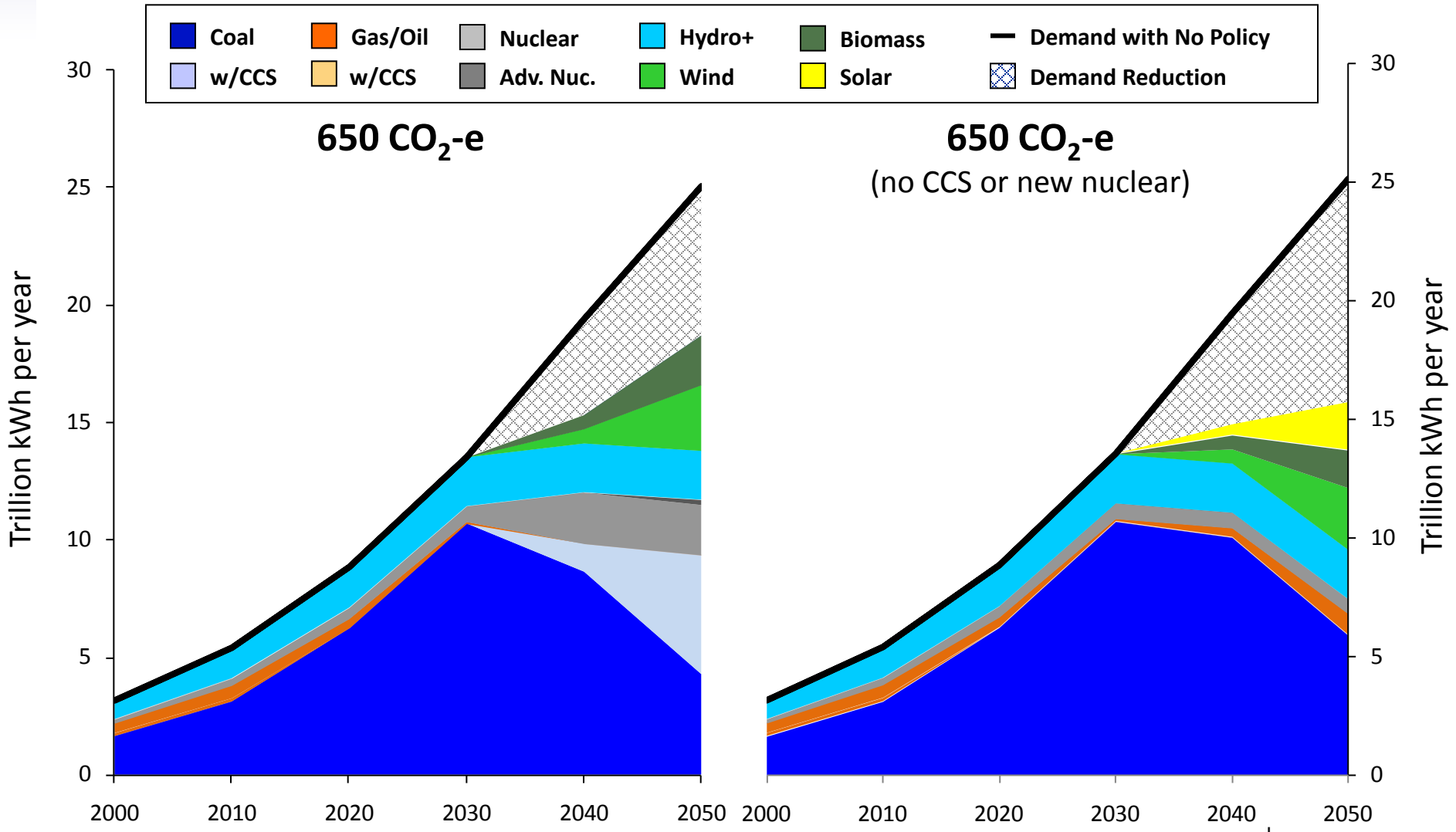
Electric Generation in BRIC (Effect of Technology)



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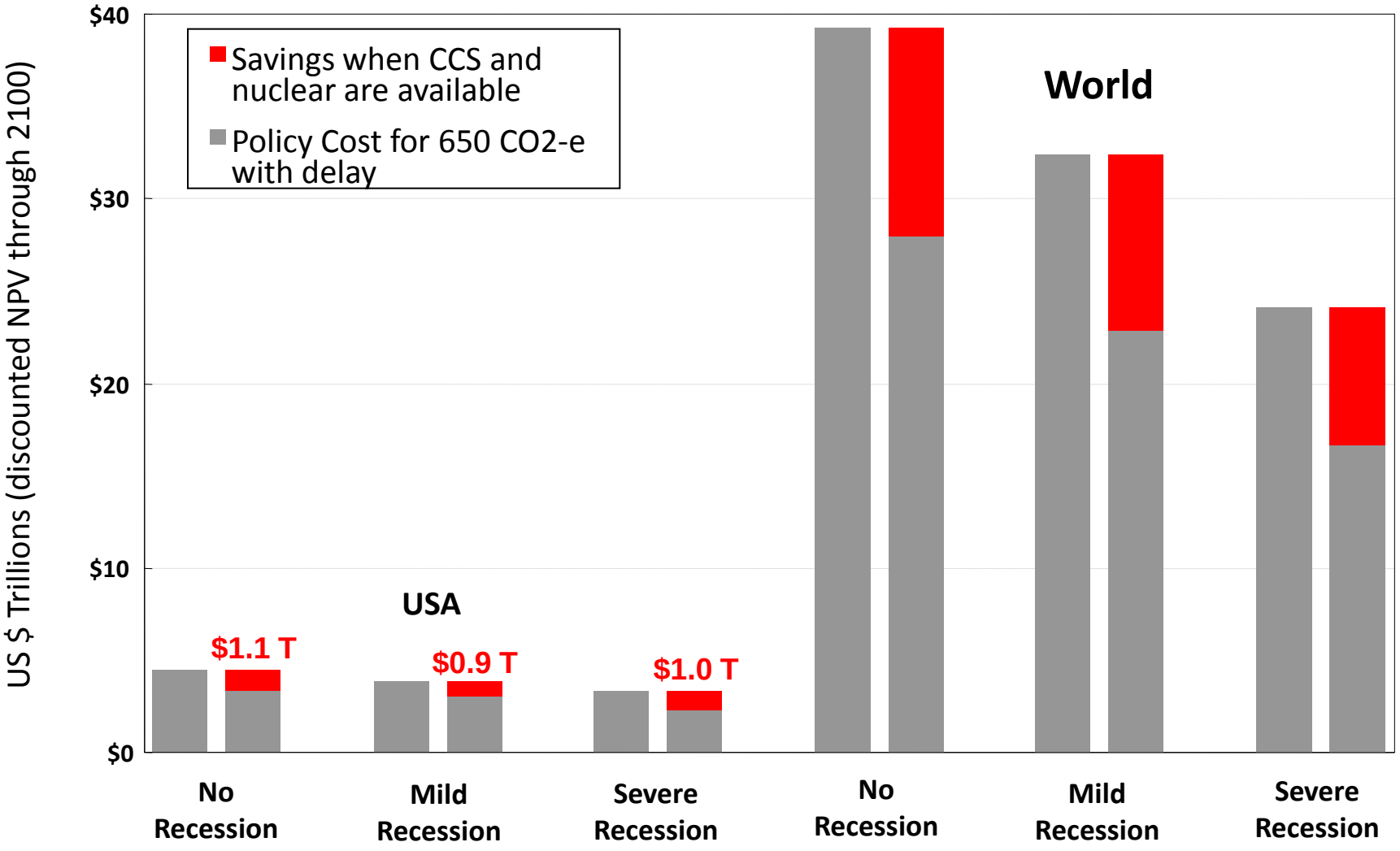
Value of Technology: CCS and New Nuclear



Conclusions

- Aggressive not-to-exceed targets for global climate variables depend critically on abatement outside of the OECD
  *(in **addition** to OECD abatement)*

- Once they are participating, developing countries present huge opportunity for technology:
  - Fast growth means more new capital needs
  - Scale is much larger: 80% of population is outside OECD
  - The sooner the better (for all concerned)

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